[REVIEW]

Practical Evaluation and Management of Atrophic Acne Scars

Tips for the General Dermatologist

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ABSTRACT

Atrophic acne scarring is an unfortunate, permanent complication of acne vulgaris, which may be associated with significant psychological distress. General dermatologists are frequently presented with the challenge of evaluating and providing treatment recommendations to patients with acne scars. This article reviews a practical, step-by-step approach to evaluating the patient with atrophic acne scars. An algorithm for providing treatment options is presented, along with pitfalls to avoid. A few select procedures that may be incorporated into a general dermatology practice are reviewed in greater detail, including filler injections, skin needling, and the punch excision.
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Acne is a common condition that affects up to 80 percent of the adolescent population to some degree or another.[1,2] Permanent scarring from acne is an unfortunate complication of acne vulgaris. The incidence of acne scarring is not well studied, but it may occur to some degree in 95 percent of patients with acne vulgaris.[3] Studies report the incidence of acne scarring in the general population to be 1 to 11 percent.[4,5]

Having acne scars can be emotionally and psychologically distressing to patients. Along with acne, having acne scars is a risk factor for suicide[6] and also may be linked to poor self esteem, depression, anxiety, altered social interactions, body image alterations, embarrassment, anger, lowered academic performance, and unemployment.[7–9] Rather than fading with time, the appearance of scars often worsens with normal aging or photodamage.[9]

Acne scars can be classified into three different types—atrophic, hypertrophic, or keloidal. Atrophic acne scars are by far the most common type. The pathogenesis of atrophic acne scarring is not completely understood, but is most likely related to inflammatory mediators and enzymatic degredation of collagen fibers and subcutaneous fat.[10] It is not clear why some acne patients develop scars while others do not, as the degree of acne does not always correlate with the incidence or severity of scarring. The scarring process can occur at any stage of acne[10]; however, it is uniformly believed that early intervention in inflammatory and nodulocystic acne is the most effective way of preventing post-acne scarring. Once scarring has occurred, it is usually permanent.

Because of the prevalence of acne scarring and the strong negative emotions it engenders in affected patients, it is likely that dermatologists will be questioned about treatment options. This article is intended to arm the general or cosmetic dermatologist with the ability to efficiently evaluate the acne scar patient, discuss the most appropriate treatment options, effectively set expectations, and decide which procedures can be done efficiently in a general dermatology clinic, and when the patient should be referred for more complicated or aggressive surgical procedures. This last item is problematic, as every dermatologist has a different skill set, comfort level performing procedures, training, and access to surgical devices or instruments. This article will not review comprehensively the literature relating to acne scars, nor will it give a step-by-step description of all techniques for treating acne scars. This article is intended to be a practical overview of the evaluation and management of the patient with acne scarring, highlighting pitfalls to avoid and discussing in more detail a few select procedures that can be most easily incorporated into a dermatology practice. This article will be limited to the evaluation and management of

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atrophic lesions only. Several other articles have adressed the management of keloidal acne scarring in detail.[9,11–13]

EVALUATION

Success in the management of the acne scar patient hinges on the physician's clear understanding of the patient's concerns and expectations relating to his or her scars. This management begins when the patient asks a question such as, "Doc, what can be done for my acne scars?" Before answering this question, the physician needs to attempt to find out the depth of the discussion the patient is seeking. In doing so, the physician should ask such questions as, "What bothers you about your scars?" "How distressing are the scars to you?" These types of questions should elicit this information. A history of the patient's acne and acne scars should be taken (see Table 1 for a list of appropriate questions), including if and when acne cleared completely and if oral isotretinoin was utilized, as many procedures are contraindicated within six months of discontinuation of isotretinoin. It is important to ask the patient if there are specific scars, areas of scarring, or features of the scars that are most bothersome. Targeting certain scars or certain features of the scars (hyperpigmentation, for example) may increase the chance of successful treatment and patient satisfaction.

Pearls for the physician examination are listed in Table 1. It is helpful to have overhead rather than direct lighting to accentuate the appearance of scars. Often, a handheld mirror will allow the patient to highlight specific areas and help them feel as though they are completely understood. Multiple acne scar grading classification systems of varying complexities have been introduced. The most basic, practical, system divides atrophic acne scars into the following three main types: 1) icepick, 2) rolling, and 3) boxcar scars (Figure 1).[14] It is common for patients to have more than one type of scar.

A second, useful system proposed by Goodman[15] uses a four-scale grading system (Table 2). During the evaluation, scars are visually inspected, palpated, and stretched. It is important to note whether or not active inflammatory acne is present, as this may be a contraindication for treatment. In addition, improving active acne may satisfy the patient even without interventions for acne scars. The skin is stretched to distinguish between grade 3 and 4 acne scars and to determine if volumizing fillers or a facelift may minimize appearance of scars. Palpation for underlying fibrosis is important, as deeply fibrotic lesions often will only improve with excisional procedures. The patient's skin type should be noted, as patients with Fitzpatrick skin types III to VI have a higher risk of postinflammatory hyperpigmentation (PIH) with many resurfacing procedures. In addition, any discoloration is noted, including hyperpigmentation, hypopigmentation, and red/purple discoloration.

MANAGEMENT

An initial discussion with the patient to address goals, concerns, and expectations is of paramount importance. Patient-specific issues are discussed (Table 3), such as the

TABLE 1. Pearls for evaluation

HISTORY
Which aspects of the patient's scarring are the most bothersome to him/her?
How distressed is the patient about his or her scars?
What are the patient's goals for treatment?
Have any prior procedures been performed to treat the scars?
Has the active acne cleared completely? How recently did the acne clear?
Was isotretinoin used? How recently was it discontinued?
Is there a history of postinflammatory hyperpigmentation (PIH)?
Is there a history of keloids or hypertrophic scars?
PHYSICAL EXAMINATION
Direct overhead lighting is optimal
Have a mirror for the patient to point out lesions
Evaluate for active acne
Define types of scars (icepick, rolling, boxcar, severely atrophic/sclerotic)
Assess color (hypopigmentation, hyperpigmentation, purple/red discoloration)
Assess depth of the lesions
Stretch skin to see if scars disappear
Palpate for underlying fibrosis
Evaluate skin type (types III–V have increased risk of PIH with most procedures)

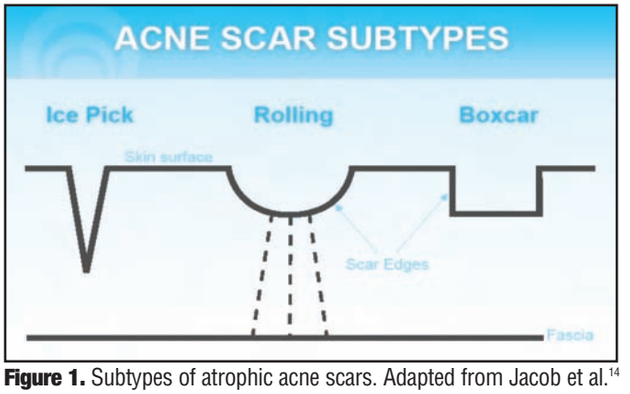

Figure 1. Subtypes of atrophic acne scars. Adapted from Jacob et al.[14]

TABLE 2. 4-Point Grading Scale for Acne Scars[15]
GRADE 1: MACULAR
• Erythematous, hyper-, or hypopigmented marks
GRADE 2: MILD DISEASE
• Mild atrophy, can be covered with makeup or facial hair
GRADE 3: MODERATE DISEASE
• Moderate scarring, not covered by makeup but can be flattened by manual stretching of the skin
GRADE 4: SEVERE DISEASE
• Scarring not flattened with manual stretching of the skin

TABLE 3. Patient-specific issues to address in treatment planning
• Expectations and goals
• Financial considerations
• Are there time constraints that need to be considered? (Family photos, wedding, job interviews, presentations, sales calls)
• How much downtime can the patient tolerate? 1) A non-ablative laser or needling procedure will have less down-time than fractional ablative laser. 2) An excisional procedure will heal more quickly than CROSS chemical peels, dermabrasion, and ablative resurfacing 3) A filler procedure may have less bruising and postoperative swelling than subcision
• How much discomfort is the patient willing to tolerate?

TABLE 4. Acne scar procedures grouped by procedure type
RESURFACING PROCEDURES
Chemical Peels
• Full Face
• CROSS Technique
Dermabrasion
Laser Resurfacing
• Ablative/nonablative
• Fractional
LIFTING PROCEDURES
Subcision
Fillers
• Directly under scars
• Volumizing
• Autologous fat transfer
Punch evaluation
EXCISIONAL TECHNIQUES
Punch excision
Elliptical excision
Punch grafting
OTHER
Skin needling
Facelift
Combination techniques

patient's goals for treatment, ability to tolerate downtime and pain, time constraints, and financial constraints. The physician should emphasize to the patient the unpredictability of acne scar treatment, specifically, that there is usually no quick, easy, and permanent fix to this problem. While there are many effective treatments for many patients, not all improve with a specific procedure or groups of procedures. Usually, multiple procedures are required and some procedures may need to be repeated at certain intervals to maintain the improvement. The only procedures that predictably have more permanence are excisional procedures and permanent fillers, such as silicone. A mistake in the initial consultation would be to promise a certain level of improvement in acne scars or to minimize the downtime and discomfort associated with each procedure that is considered. Patients are most likely to be satisfied with their outcome (even if they have only marginal results) if the physician can help them understand the unpredictability of acne scar therapy and develop realistic expectations for improvement. In addition, side effects of each procedure planned should be discussed in detail. The risks of infection, hyperpigmentation, prolonged erythema, swelling, and poor healing/scarring are present with many procedures and should be understood by the patient.

SELECTING THE APPROPRIATE PROCEDURES

Available procedures for acne scars are listed by category in Table 4. Resurfacing procedures remove layers of skin from the top down. Injury to the dermis by resurfacing procedures is thought to cause dermal remodeling and neocollagenesis. Lifting procedures attempt to draw the base of a deep scar upward towards the surface, making the skin smooth. Excisional procedures remove scars completely. Table 5 lists the most appropriate procedures to utilize for each lesion type (e.g., rolling, boxcar). If a patient has scars of varying morphologies, two or more different procedures may need to be selected (e.g., punch excisions of icepick scars and filler injections under soft, rolling scars). It is wise to do a test spot in a representative area that is in as inconspicuous of a location as possible. This may address the efficacy of a procedure and also predict the risk for side effects, such as prolonged erythema or PIH. Selecting the appropriate locations is important, as acne scars on the chest, back, and shoulders are much more resistant to treatment than scars on the face.

PROCEDURES MOST EASILY INCORPORATED INTO A GENERAL OR COSMETIC DERMATOLOGY PRACTICE

There are a few procedures that can be easily

incorporated into most general dermatology practices with much less expense and training in comparison with lasers, subcision, dermabrasion, or other procedures. These procedures are soft-tissue augmentation fillers, the punch excision, and skin needling.

Soft tissue augmentation fillers. Soft-tissue fillers are effective in treating patients with rolling acne scars.[16–21] Because many dermatologists are comfortable using these materials in patients for cosmetic purposes, the transition to treatment of acne scars with these same agents is natural. Fillers for acne scarring can be utilized in two ways. First, fillers can be injected directly under individual scars for immediate improvement (Figure 2). Second, volumizing fillers, such as poly-L lactic acid or calcium hydroxylapatite, can be delivered to areas where laxity of skin or deep tissue atrophy is accentuating the appearance of acne scars (Figure 2).

Fillers injected directly under scars. Normally, cross-linked hyaluronic acid fillers are utilized for local injection under specific scars. The filler can be injected either with a cross-hatching/lattice approach or a depot injection under the scars. The optimal lesions are broad, rolling scars that are soft and distensible/stretchable. Caution should be taken if there is fibrosis under the lesion, as the deposition of filler may be uneven under the scar, resulting in extrusion of the filler material into the surrounding skin, which could possibly make the appearance worse. In addition, it is important to not deliver too much filler. It would be better to undercorrect and do touch-up treatments in the future.

Volumizing fillers. Volumizing fillers such as poly-L lactic acid (Scupltra®, Sanofi-Aventis, Paris, France) or calcium hydroxylapatite (Radiesse®, Bioform Medical Inc., Milwaukee, WI) are also widely utilized by dermatologists for volumetric replacement of deep tissue atrophy of the mid-face or for human immunodeficiency virus (HIV) lipatrophy. Atrophic acne scars in some patients are accentuated by skin laxity or loss of volume in the cheek or chin area, similar to a deflated balloon that wrinkles and has multiple depressions. These changes often worsen in appearance with age or photodamage.[9] When the skin is stretched, similar to a balloon being refilled, individual depressions and shadows are naturally minimized (Figure 3). The same techniques used to inject poly-L lactic acid and calcium hydroxylapatite for correction of HIV lipatrophy and for cosmetic augmentation of the mid-face can be used when treating acne scars. The material is placed either by periosteal depot or diffusely in the area of deep tissue atrophy to swell and lift the area as is described in other studies.[22–26]

Skin needling. Skin needling, also called "collagen induction therapy"[27] or "needle dermabrasion"[28] is the technique of rolling a device composed of a barrel studded with hundreds of needles, which create thousands of micropunctures in the skin to the level of the papillary to mid-dermis (Figures 4 and 5). The optimal scars to treat with skin lesion are the same as fractional laser resurfacing—rolling acne scars, superficial boxcar scars, or erythematous

TABLE 5. Procedures to select/recommend by lesion type

ICE-PICK SCARS
Punch excision
CROSS chemical peels
ROLLING SCARS
Subcision
Filler injections directly underneath scars
Fractional laser therapy
Skin needling
BOXCAR SCARS
CROSS chemical peels (for small lesions)
Punch elevation
Fractional laser therapy
Skin needling
Focal dermabrasion
Punch excision (for narrow, deep lesions)
Elliptical excision (for larger lesions)
MACULAR GRADE 1 SCARRING (REDNESS, HYPOPIGMENTED OR HYPERPIGMENTED)
Skin needling
Fractional ablative/nonablative laser
Nonablative laser for pigment (erythema or hyperpigmentation)
ReCell (in future)
FIBROTIC OR DEEP, HYPOPGMENTED SCARS
Excisional techniques

Figure 2. Photos before (A) and after (B) hyaluronic acid filler injected immediately beneath rolling acne scars of the lower face. This patient was also treated with botulinum toxin to the lower face.

Photos courtesy of Greg Goodman, MD

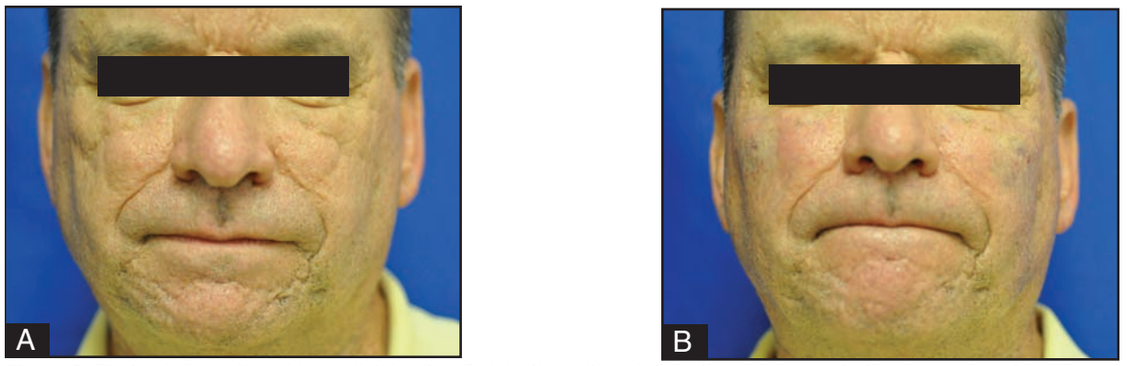

Figure 3. Photos before (A) and immediately after (B) injection with poly-L lactic acid demonstrating how volumetric filling of the mid-face can improve the appearance of acne scars accentuated by underlying soft tissue loss. Although this effect is temporary, it approximates what the patient will ultimately achieve with 2 to 4 sessions of treatment.

Figure 4. Needling device consisting of a rolling barrel studded by 2mm-long needles

or hypopigmented macular (grade 1) scars. The proposed mechanism by which skin needling improves acne scars is as follows: The dermal vessels are wounded, causing a cascade of events including platelet aggregation, release of inflammatory mediators, neutrophil, monocyte, and fibroblast migration, production and modulation of extracellular matrix, collagen production, and prolonged tissue modulation.[29]

Prior to the treatment, topical anesthetic is applied for one hour. Oral anxiolytic medications, oral or intramuscular opioid analgesics, and forced cold air may also aid in patient comfort.

A sterile rolling device with needles of length 1.5 to 2.5mm is rolled across the skin with pressure in multiple directions until the area demonstrates uniform pinpoint bleeding through thousands of micropuncture sites. One study[30] describes rolling the device four times in four different directions (horizontally, vertically, and diagonally right and left) for a total of 16 passes. In the author's experience, the number of passes required to achieve uniform pinpoint bleeding of the treatment area is variable and is inversely proportional to the density of the needles on the rolling barrel. After the procedure, the area is cleansed with saline-soaked gauze and an occlusive ointment is applied. Generally, the skin oozes for less than 24 hours and then remains erythematous and edematous for 2 to 3 days. Usually, three or more treatments are required to achieve optimal clinical benefit, separated by four-week intervals.

Compared to other resurfacing procedures, this technique has many advantages. First, it is purported to be safe in all skin types and to carry the lowest risk of PIH when compared to laser resurfacing, chemical peels, or dermabrasion.[31] Second, the treatment does not result in a line of demarcation between treated and untreated skin, as usually occurs with other resurfacing procedures. This allows for specific areas of scarring to be treated without the need to treat the entire face or to "blend" or "feather" at the treatment edges. Third, the recovery period of 2 to 3 days is significantly shorter than other resurfacing procedures. Finally, needling is much less expensive to incorporate into a practice compared with a fractional laser or dermabrasion. There are no studies comparing the efficacy of skin needling to the efficacy of other resurfacing procedures.

Punch excision. Some scars that are deep or prominent are optimally removed with excisional surgical procedures. The punch excision of icepick acne scars or deep boxcar scars is a technique that can be easily adopted into a dermatology practice. Most dermatologists are comfortable doing punch biopsies of small pigmented nevi or of inflammatory dermatoses. The same technique is used to remove appropriate acne scars. A disposable punch biopsy instrument is selected that matches the size of the icepick or narrow boxcar scar, including the walls of the scar. These instruments come in half sizes from 1.5mm to 3.5mm. The area is infiltrated with 1% lidocaine with epinephrine (1:100,000). The scar and its walls are excised down to the subcutaneous fat layer and are carefully removed with fine forceps and iris scissors, and 6-0 polypropylene sutures are placed to close the wound, with care taken to evert the wound edges.[14] One to three sutures are placed, depending on the size of the wound created. The wound is dressed with occlusive ointment and a bandage, and the sutures are removed in seven days.

Scar spreading and suture track marks are two problems

that can occur with punch excisions. Jacob et al[14] describe the value of placing a single buried suture using 6-0 Vicryl suture (Ethicon, Inc, Somerville, New Jersey) for punch holes that are 2.5mm and greater to facilitate wound healing and minimize spreading. To minimize suture track marks, it is important that the epidermal 6-0 polypropylene sutures are not tightened excessively and that they are removed no more than seven days after the procedure. A caveat to performing excisional procedures on patients with acne scars is that some of these patients have a defect in wound healing, which may explain the reason they developed acne scars in the first place, and do not heal well from excisional procedures. It may be wise to do a test spot by performing a punch excision on a scar in an inconspicuous location before performing extensive punch excisions on the same patient. Scars that are larger than 3.5mm are better excised with an elliptical excision (Figure 6). For dermatological surgeons who are comfortable operating on the face, the transition from excision of benign and malignant lesions on the face to the elliptical excision of scars is a natural process.

The CROSS technique is used for ice-pick and narrow boxcar scars.[32] A high-strength trichloroacetic acid (TCA) peel solution is placed in the base of these scars to ablate the epithelial wall and to promote dermal remodeling.

Punch elevation is a technique used to treat perfectly circular boxcar scars without underlying fibrosis.[10] A punch biopsy tool is used to incise the scar and allow it to float upward. It is then secured in place by sutures, tape, or cyanoacrylate skin glue.

Fat transfer is an alternative to the volumizing fillers for patients whose scarring is exaggerated by lax skin or soft tissue loss. Permanent fillers, such as medical-grade liquid silicone and Artefill (currently off the market in the United States), have been used in expert hands for improvement of atrophic acne scars.

Ablative and nonablative fractional lasers may be effective for all types of atrophic acne scars except for deep icepick scars. Often a combination of techniques (e.g., subcision or filler injections combined with fractional resurfacing) will yield a superior result compared to one

OTHER PROCEDURES

Other procedures that are well described for treating acne scars are subcision, punch elevation, dermabrasion, chemical reconstruction of skin scars (CROSS) chemical peels, fat transfer, permanent fillers, and ablative and nonablative fractional laser therapy. Patients can be referred to a dermatological surgeon who has the equipment and expertise to perform these procedures, or the techniques can be learned by the general dermatologist. These procedures and their indications will be briefly reviewed.

Subcision, also called "subdermal/incisionless undermining," is indicated for the same types of scars that might be improved with fillers (i.e., rolling scars in which appearance is improved with manual stretching of the skin during examination).[13] Subcision may yield longer term results than fillers.

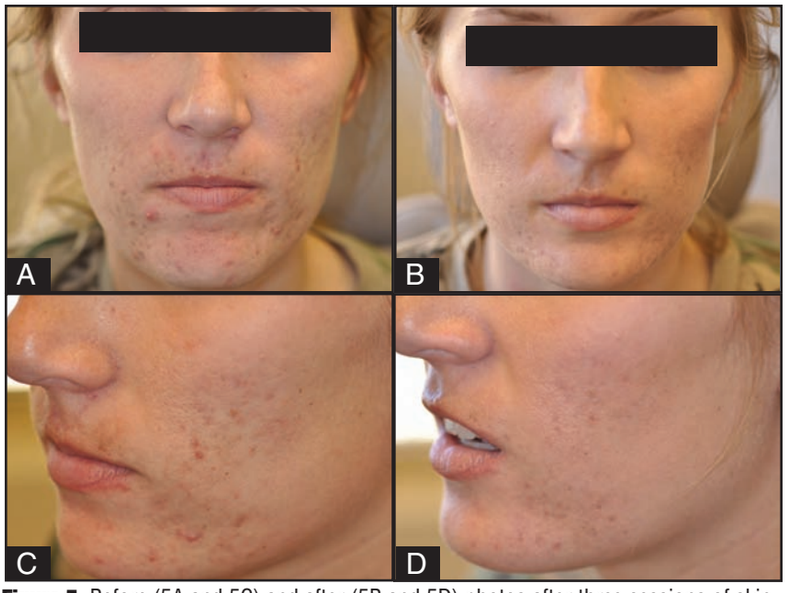

Figure 5. Before (5A and 5C) and after (5B and 5D) photos after three sessions of skin needling. Although some of the improvement is from clearance of active acne, the patient also noticed improvement of her atrophic acne scars.

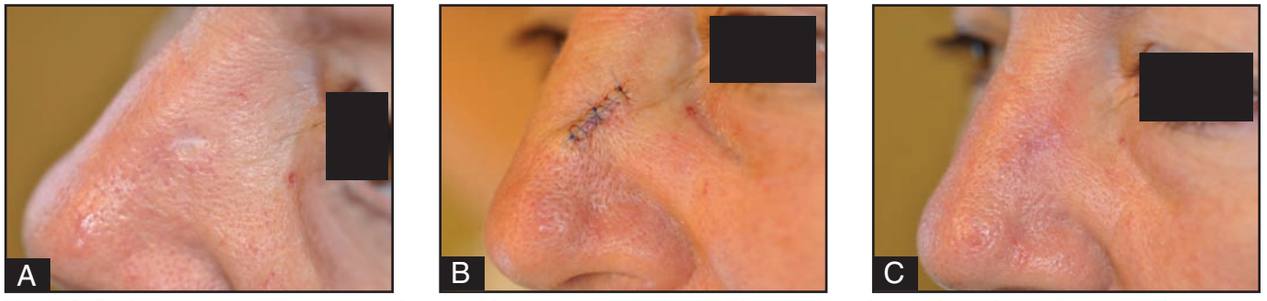

Figure 6. Elliptical excision of a hypopigmented, sclerotic boxcar scar. Pretreatment (A), immediately postoperatively (B), one month postoperatively (C) showing improvement in color and contour

Pearls for management
• Treat active acne before procedures for acne scars are initiated
• Allow red/purple macular discoloration to resolve before full evaluation and treatment of atrophic scars
• Set appropriate expectations. Emphasize that improvement is unpredictable, often multiple procedures are required. The goal should be improvement in acne scars and not total cure.
• Consider excisional techniques for fibrotic, deep, or markedly hypopigmented lesions (acne excoriee)
• In older patients with lax skin or soft tissue atrophy, consider volumizing fillers (calcium hydroxylapetite or poly-L-lactic acid) or referral for facelift
• Globally evaluate patient's appearance (there may be more "slam dunk" procedures, such as removal of facial moles or botulinum toxin, that may have more dramatic improvement)

Pitfalls to avoid
• Failure to set appropriate expectations
• Promising a certain level of improvement
• Failure to notice patients with unrealistic hopes or demands
• Inadequate questioning about history of PIH
• Failure to assess time constraints (patient will be unhappy if there is postprocedure erythema or hyperpigmentation for an important event)
• Treating a large area with an aggressive procedure before doing a test spot

procedure alone). In addition, nonablative large-spot lasers have been utilized effectively for treating atrophic acne scars.[33]

CONCLUSION

Due to the prevalence of acne scarring and the emotional distress it causes to those affected, dermatologists are likely to be presented with the challenge of evaluating and managing patients with atrophic acne scars. Having an approach to efficiently evaluate and develop an appropriate treatment plan for these patients will increase the chances for patient satisfaction. Setting the appropriate expectations and goals for improvement is imperative during the initial consultation. Prior to the initiation of any procedures, it is of utmost importance to frankly discuss the unpredictability of results in acne scar therapy and the possible need for multiple procedures over a period of time. Selecting the most appropriate procedures for each lesion type will increase the chance of success. For the treatment of atrophic acne scars, the punch excision, injection of dermal and volumizing fillers, and skin needling are procedures that can be easily incorporated into a dermatology practice, providing the general dermatologist with a valuable opportunity not only to improve a patient's acne scarring but also to enhance self esteem so often impacted by the long-lasting effects of acne scarring.

REFERENCES

1. Kranning KK, Odland GF. Prevalence, morbidty and cost of dermatological diseases. *J Invest Dermatol*. 1979;73(Suppl): 395–401.
2. Johnson MT, Roberts J. Skin conditions and related need for medical care among persons 1 to 74 years. United States, 1971–1974. Vital Health Stat 11. 1978;(212):i–v, 1–72.
3. Layton AM, Henderson CA, Cunliffe WJ. A clinical evaluation of acne scarring and its incidence. *Clin Exp Dermatol*. 1994:19:303–308.
4. Cunliffe WJ, Gould DJ. Prevalence of facial acne vulgaris in late adolescence and in adults. *Br Med J*. 1979;1(6171): 1109–1110.
5. Goulden V, Stables GI, Cunliffe WJ. Prevalence of facial acne in adults. *J Am Acad Dermatol*. 1999:41:577–580.
6. Cotterill JA, Cunliffe WJ. Suicide in dermatologic patients. *Br J Dermatol*. 1997;137:246–250.
7. Koo JY, Smith LL. Psychologic aspects of acne. *Pediatr Dermatol*. 1991;8:185–188.
8. Koo J. The psychosocial impact of acne: patients' perceptions. *J Am Acad Dermatol*. 1995;32(Suppl):S26–S30.
9. Rivera AE. Acne scarring: A review and current treatment modalities. *J Am Acad Dermatol*. 2008;59(4):659–676.
10. Goodman GJ, Baron JA. The management of postacne scarring. *Dermatol Surg*. 2007;33(10):1175–1188.
11. Miteva M, Romanelli P. Hypertrophic and keloidal scars. In *Acne Scars: Classification and Treatment*. Tosti A, Pie De Padova M, Beer K, eds. London: Informa Healthcare; 2010: 11–19.
12. Shockman S, Paghdal KV, Cohen G. Medical and surgical management of keloids: a review. *J Drugs Dermatol*. 2010;9(10):1249–1257.
13. Tsao SS, Dover JS, Arndt KA, Kaminer MS. Scar management: keloid, hypertrophic, atrophic, and acne scars. *Semin Cutan Med Surg*. 2002;21(1):46–75.
14. Jacob CI, Dover JS, Kaminer MS. Acne scarring: a classification system and review of treatment options. *J Am Acad Dermatol*. 2001;45(1):109–117.
15. Goodman GJ, Baron JA. Postacne scarring: a qualitative global scarring grading system. *Dermatol Surg*. 2006;32(12): 1458–1466.
16. Barnett JG, Barnett CR. Treatment of acne scars with liquid silicone injections: 30-year perspective. *Dermatol Surg*. 2005;31(11 Pt 2):1542–1549.
17. Beer K. A single-center, open-label study on the use of injectable poly-L-lactic acid for the treatment of moderate to severe scarring from acne or varicella. *Dermatol Surg*.

2007;33 Suppl 2:S159–S167.
18. Epstein RE, Spencer JM. Correction of atrophic scars with Artefill: an open-label pilot study. *J Drugs Dermatol*. 2010;9(9):1062–1064.
19. Goldberg DJ, Amin S, Hussain M. Acne scar correction using calcium hydroxylapatite in a carrier-based gel. *J Cosmet Laser Ther*. 2006;8(3):134–136.
20. Sadove R. Injectable poly-L-lactic acid: a novel sculpting agent for the treatment of dermal fat atrophy after severe acne. *Aesthetic Plast Surg*. 2009;33(1):113–116. Epub 2008 Oct 16.
21. Sadick NS, Palmisano L. Case study involving use of injectable poly-L-lactic acid (PLLA) for acne scars. *J Dermatolog Treat*. 2009;20(5):302–307.
22. Beer K, Yohn M, Cohen JL. Evaluation of injectable CaHA for the treatment of mid-face volume loss. *J Drugs Dermatol*. 2008;7(4):359–366.
23. Carruthers A, Carruthers J. Evaluation of injectable calcium hydroxylapatite for the treatment of facial lipoatrophy associated with human immunodeficiency virus. *Dermatol Surg*. 2008;34(11):1486–1499. Epub 2008 Sep 22.
24. Fitzgerald R, Vleggaar D. Using poly-L-lactic acid (PLLA) to mimic volume in multiple tissue layers. *J Drugs Dermatol*. 2009;8(10 Suppl):s5–s14.
25. Lizzul PF, Narurkar VA. The role of calcium hydroxylapatite (Radiesse) in nonsurgical aesthetic rejuvenation. *J Drugs Dermatol*. 2010;9(5):446–450.
26. Schierle CF, Casas LA. Nonsurgical rejuvenation of the aging face with injectable poly-L-lactic acid for restoration of soft tissue volume. *Aesthet Surg J*. 2011;31(1):95–109.
27. Aust MC, Fernandes D, Kolokythas P, Kaplan HM, Vogt PM. Percutaneous collagen induction therapy: an alternative treatment for scars, wrinkles, and skin laxity. *Plast Reconstr Surg*. 2008;121(4):1421–1429.
28. Camirand A, Doucet J. Needle dermabraion. *Aesthetic Plast Surg*. 1997;21(1):48–51.
29. Fabbrocini G, Fardella N, Monfrecola A. Needling. In: *Acne Scars: Classification and Treatment*. Tosti A, Pie De Padova M, Beer K, eds. London: Informa Healthcare; 2010: 57–66.
30. Fabbrocini G, Fardella N, Monfrecola A, Proietti I, Innocenzi D. Acne scarring treatment using skin needling. *Clin Exp Dermatol*. 2009;34(8):874–879. Epub 2009 May 22.
31. Fabbrocini G, Annunziata MC, D'Arco V, et al. Acne scars: pathogenesis, classification and treatment. *Dermatol Res Pract*. 2010;2010:893080. Epub 2010 Oct 14.
32. Lee JB, Chung WG, Kwahck H, Lee KH. Focal treatment of acne scars with trichloroacetic acid: chemical reconstruction of skin scars method. *Dermatol Surg*. 2002;28(11): 1017–1021.
33. Keller R, Belda Júnior W, Valente NY, Rodrigues CJ. Nonablative 1,064-nm Nd:YAG laser for treating atrophic facial acne scars: histologic and clinical analysis. *Dermatol Surg*. 2007;33(12):1470–1476.